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CHEMICAL BIOLOGICAL CENTER  
U.S. ARMY SOLDIER AND BIOLOGICAL CHEMICAL COMMAND

ECBC-TR-096

**M-9 CHEMICAL PAPER  
ALTERNATIVE PLASTIC DISPENSER FEASIBILITY STUDY**

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## PREFACE

The work described in this report was authorized under Sales Order No. 7MAW11. The work was started in March 1997 and completed in June 1997.

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# **M-9 CHEMICAL PAPER ALTERNATIVE PLASTIC DISPENSER FEASIBILITY STUDY**

## **1. INTRODUCTION**

This study was conducted to evaluate the feasibility of replacing the existing cardboard dispenser for the M-9 chemical agent detection paper with a plastic dispenser to reduce costs. The study estimated manufacturing, prototype and testing costs, and evaluated possible polymers for the dispenser. Material research was focused on possible reactions between the chemical paper, the dispenser, and the mechanical stability of different materials.

The feasibility was based upon the following constraints.

- Cost analysis between the existing dispenser and the new design
- Interaction between the plastic polymer and the SR119 detection paper
- Long term storage of the dispenser

Concerns were focused on the emissions of the polymer due to the natural degradation of the material. One specific concern was whether these emissions will contaminate the detection paper.

The existing dispenser produced at a rate of 500,000 units/year. The cost for the dispenser was \$ .50 each in its existing form. This value was the basis upon which the cost estimate will be compared. Conceptual designs were developed to show possible alternative dispensers. The cost of the designs were estimated for the injection molding process. This was used to determine whether to continue with the development of the new dispenser.

The chemical paper detects G, H, V, and L agents. The composition of the paper was a wood pulp matrix mounted on a mylar substrate. The paper matrix contained several dyes that produced its color. The active dye was SR119 red. Chemical agent dissolved the SR119 causing red spots to appear on the paper.

## **2. POLYMER RESEARCH**

The material research was geared towards finding a polymer that will not contaminate the paper. This task was approached from two paths. The first approach was to find a material that has been deemed acceptable already. The second approach was to determine what would cause the contamination and choose a material that did not have these properties. In the existing unit, there are several polymer materials used.

A silicone emulsion was used to increase the water and scuff resistance of the paper. The paper matrix was mounted on a mylar substrate. The heat-sealed packaging was made from polyolefin, and the resealable bag was made from polyethylene.

The functionality of the paper makes it hard to determine what reacted with the paper. There was no direct property that caused the dye to dissolve. Southern Research Institute conducted experimentation on the M-9 paper in 1983. The active dye in the paper was B-1 at that time. The experimentation was to increase the water and scuff resistance of the paper. These experiments entailed embedding several polymer emulsions into the paper matrix. The results showed how several polymers reacted with the paper when directly combining the two. However, the experimentation did not provide enough information to justify a material selection. The experiments were based upon accelerated shelf-life testing. This was used to simulate the natural aging process of the materials. This testing could be used to test the interaction between the new dispenser and the chemical paper.

The material research did not produce a polymer that would exhibit a high degree of confidence. A decision was then made to select materials with a history in chemical defense. Polyethylene and polyolefin were used in the existing dispenser. Polyethylene or any other olefin based polymer would make a sensible selection. Acrylonitrile Butadiene Styrene (ABS) is a polymer that had the ability to be decontaminated and is relatively inert. Nylon had the same features as ABS but was more expensive. Polyethylene, ABS, and nylon were materials that were probable candidates for further research.

### 3. CONCEPTUAL DESIGNS

Cost estimates were based on conceptual designs that met the functionality of the dispenser. Three conceptual designs were developed for pricing. The designs had the same mechanical working process as the existing dispenser. Injection molding was the manufacturing process that was used. This process was selected based on the high production rate. Furthermore, the process could be automated, which reduced the manufacturing cost. The rate at which the cost was based upon was 500,000 units/year. All estimates were quoted high to account for any unexpected costs. Material, tooling, and labor were included in the estimates. Assembly and labeling were not included in the cost estimate.

#### 3.1 Production Cost Estimate.

The first conceptual design (Figure 1) is a two-piece box. The shape of the box is not complex and functions similar to an ordinary packaging box. The female box half has a serrated edge as part of the molded piece. The design requires a material with high strength and rigidity. Polyethylene was not a viable selection for this concept. The estimated cost for this design was \$0.65 for the dispenser, and the tooling cost for the mold was \$21,500. This estimate was based on injection molding of ABS (color: black) plastic. The molding process evaluated was a two-cavity mold. The production run for

the 500,000 parts was 6 months. Labor cost estimates were based on \$35/hr. The processing time for the injection mold was estimated to be 25 sec between shots.

The second conceptual design was identical to that of concept one. The difference was in the serrated edge. This design had a metal edge inserted into the part during the molding process. This increased the manufacturing cost due to the increase in labor and complexity for the process. The estimated cost for this concept was \$0.75 for the dispenser. This cost included the expense of the metal edge (\$0.01/dispenser) that was inserted during the manufacturing process. The estimate was based upon the use of ABS as the molded material. A two-cavity mold and 6-month production run was used for the cost evaluation. Values for labor and time were the same as concept one.

The last conceptual design (Figure 2) was based on the existing paper box flatpattern. The design was a hinged injection molded flatpattern. The serrated metal edge was insert molded into the part similar to concept two. The flatpattern was then folded around the chemical paper roll like the existing design. This concept was ideal for the use of polyethylene. The estimated cost for the living hinge concept was \$0.40 for the part, and the tooling cost was \$18,500. This estimate was based on a single-cavity injection molding process, using polyethylene. The production logistics were the same as the previous conceptual designs. To re-emphasize, this cost did not include values for labeling or the assembly process.

The basis for the cost comparison was \$0.50/box. After further investigation, a previous manufacturer of the cardboard dispenser estimated the cost of the cardboard box to be \$0.42. The cost comparisons throughout this study were completed using the original estimate of \$0.50.

### 3.2 Prototype Cost Estimate.

The cost estimate for the hinged conceptual design was based on a production run of 500 parts. Based on the increased production cost estimates, prototype estimates were not conducted for concepts one and two. The prototyped parts were produced so that the design could be tested before a full production run was conducted. The mold for the prototype parts was made out of aluminum to reduce expense. The cost for the 500 prototype dispensers was \$10,000. This amount was based on mold design, labor, tool material, and molding material.

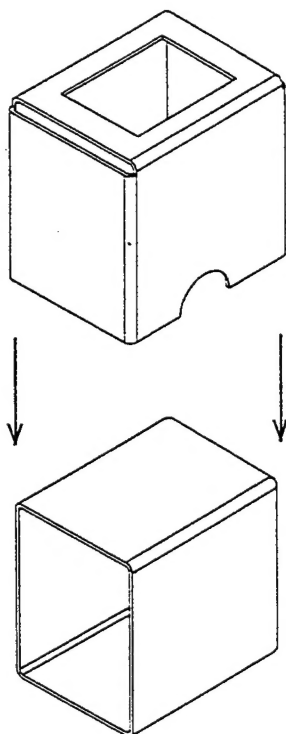
### 3.3 Testing Cost Estimate.

Physical testing was necessary to verify the effect that the polymer emissions had on the chemical paper. A storage stability test simulated accelerated degradation of the unit. The cost for testing that provided a table with the results of the trial was estimated to be \$2800. The same test, but with a full technical data report attached, was estimated to be \$4900. The latter option provided all data necessary for the experiment to be duplicated. The experimental constraints for the storage stability test for this test were 7-day trial run, tested at 90 °C, and environment is air.

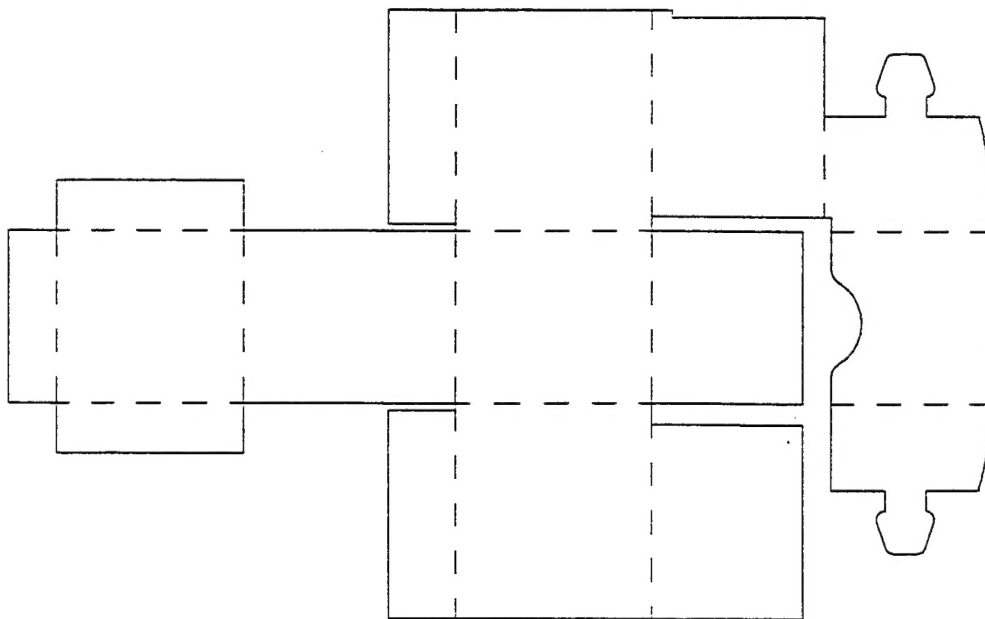
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## CONCLUSION

This study determined the feasibility of making the M-9 chemical paper dispenser out of plastic. The material evaluation provided polyethylene as the most confident material to use. From the production cost estimates, the hinged flatpattern molded dispenser was the only concept evaluated with a cost reduction (a savings of \$0.02/box). The design would lead to an overall cost reduction of \$10,000/year. This was assuming that labeling and assembling were not included in the existing dispenser cost estimate. The production costs of 500 prototype parts was \$10,000. Testing the prototype parts cost \$4900 with the full technical report provided. At the time of this study, the initial costs accrued for tooling, testing, and evaluation consumed any savings in the cost per part. Therefore, the M-9 plastic dispenser did not appear to be cost effective.



**Figure 1. Concept 1 and 2, Male and Female Box Halves**



**Figure 2. Concept 3, Hinged Flatpattern**